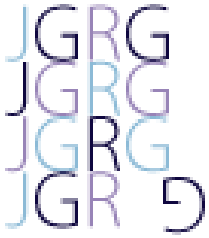
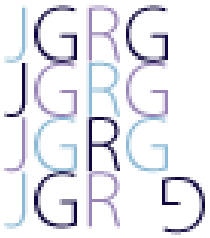


Takaaki Kajita, JGRG 22(2012)111402

"Status of KAGRA"



RESCEU SYMPOSIUM ON

GENERAL RELATIVITY AND GRAVITATION

JGRG 22

November 12-16 2012

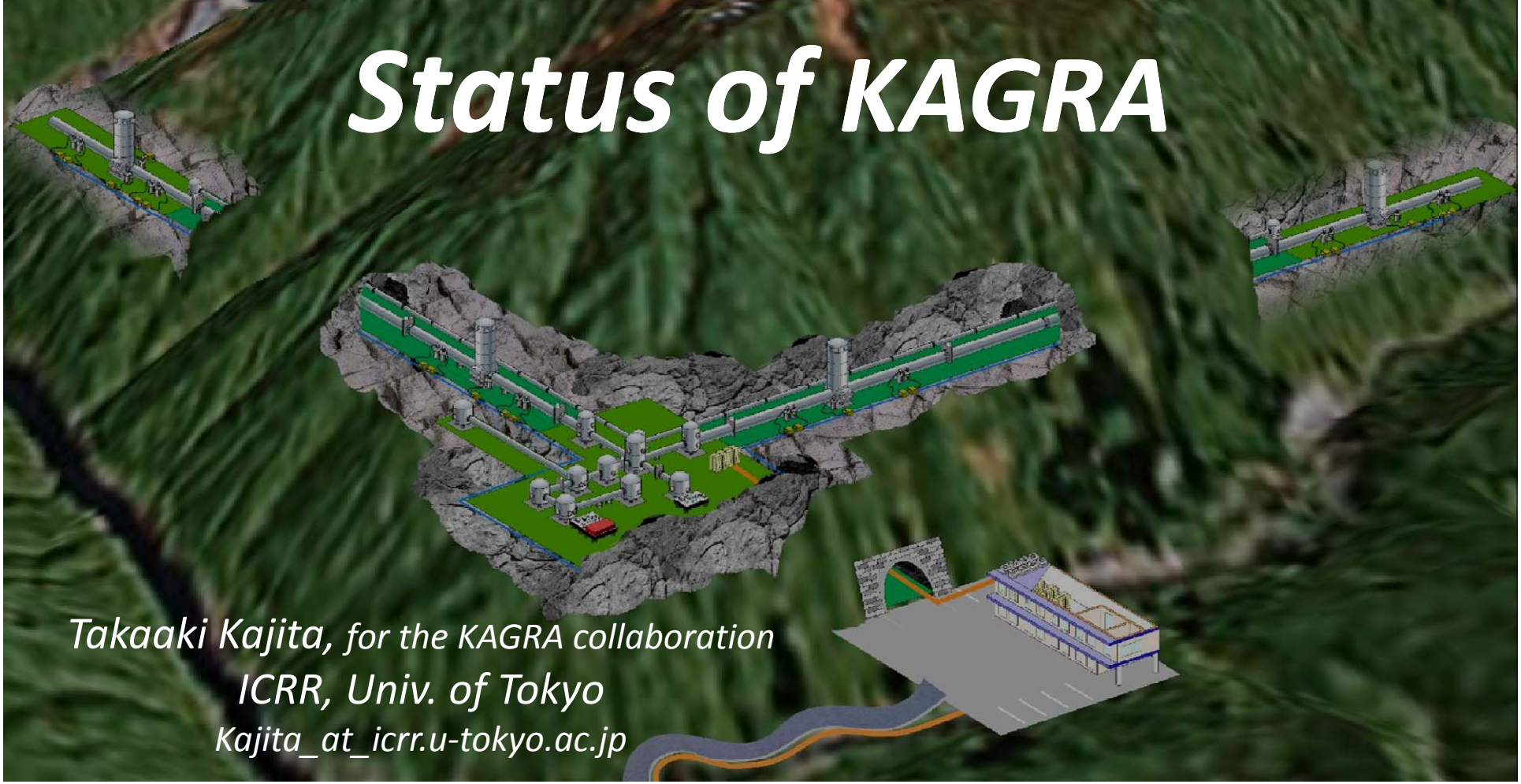
Koshiba Hall, The University of Tokyo, Hongo, Tokyo, Japan

ICRR
Institute for Cosmic Ray Research
University of Tokyo

KAGRA

RESCEU Symposium on General Relativity and Gravitation
Nov. 12-16, 2012, Tokyo

Status of KAGRA

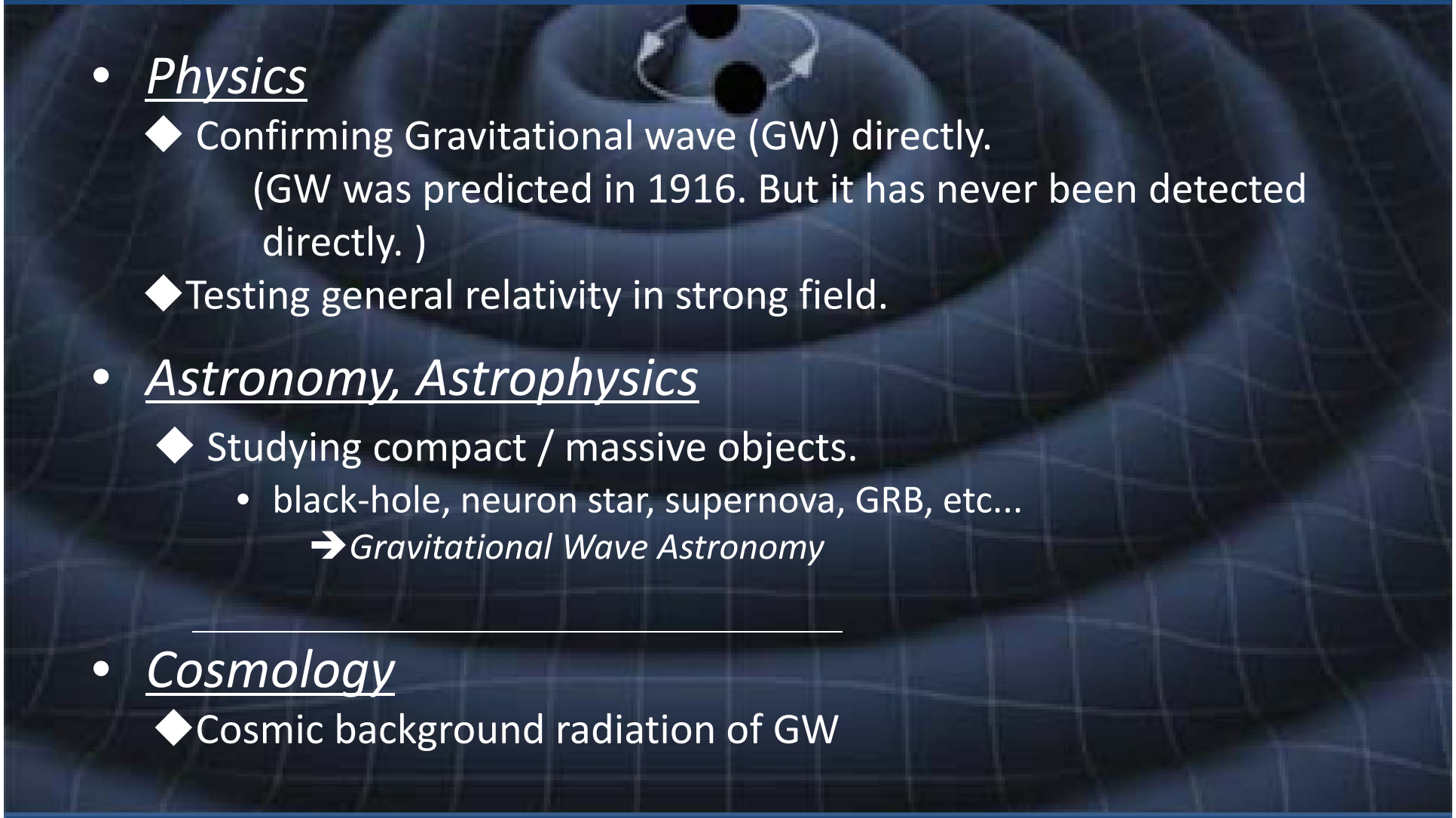


Takaaki Kajita, for the KAGRA collaboration
ICRR, Univ. of Tokyo
Kajita_at_icrr.u-tokyo.ac.jp

Outline

- General Introduction
- Overview of KAGRA
  - Key features
  - Science examples
- Status of construction
- Global GW network
- Summary

General Introduction: Why do we want to observe Gravitational Waves?



- *Physics*
  - ◆ Confirming Gravitational wave (GW) directly.
    (GW was predicted in 1916. But it has never been detected directly.)
  - ◆Testing general relativity in strong field.
- *Astronomy, Astrophysics*
  - ◆ Studying compact / massive objects.
    - black-hole, neuron star, supernova, GRB, etc...
      - ➔*Gravitational Wave Astronomy*

- *Cosmology*
  - ◆Cosmic background radiation of GW

Key requirements for high sensitivity ($\Delta L/L < 10^{-22}$)

Reduced ground motion

→*The interferometer should be build on a stable place*

→*Advanced seismic attenuation system*

Reduced thermal noise

→*Cryogenic mirrors*

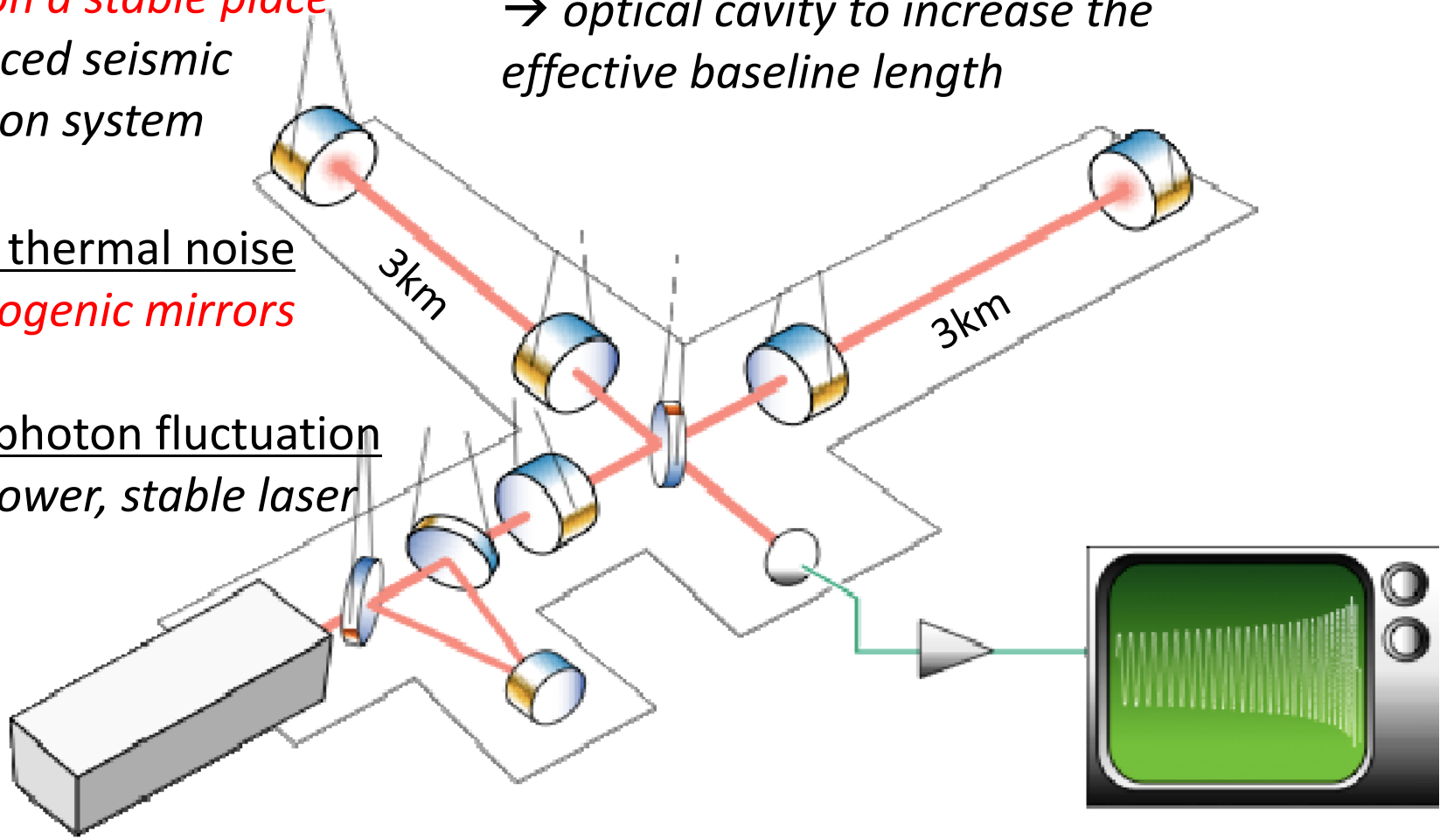
Reduced photon fluctuation

→*High power, stable laser*

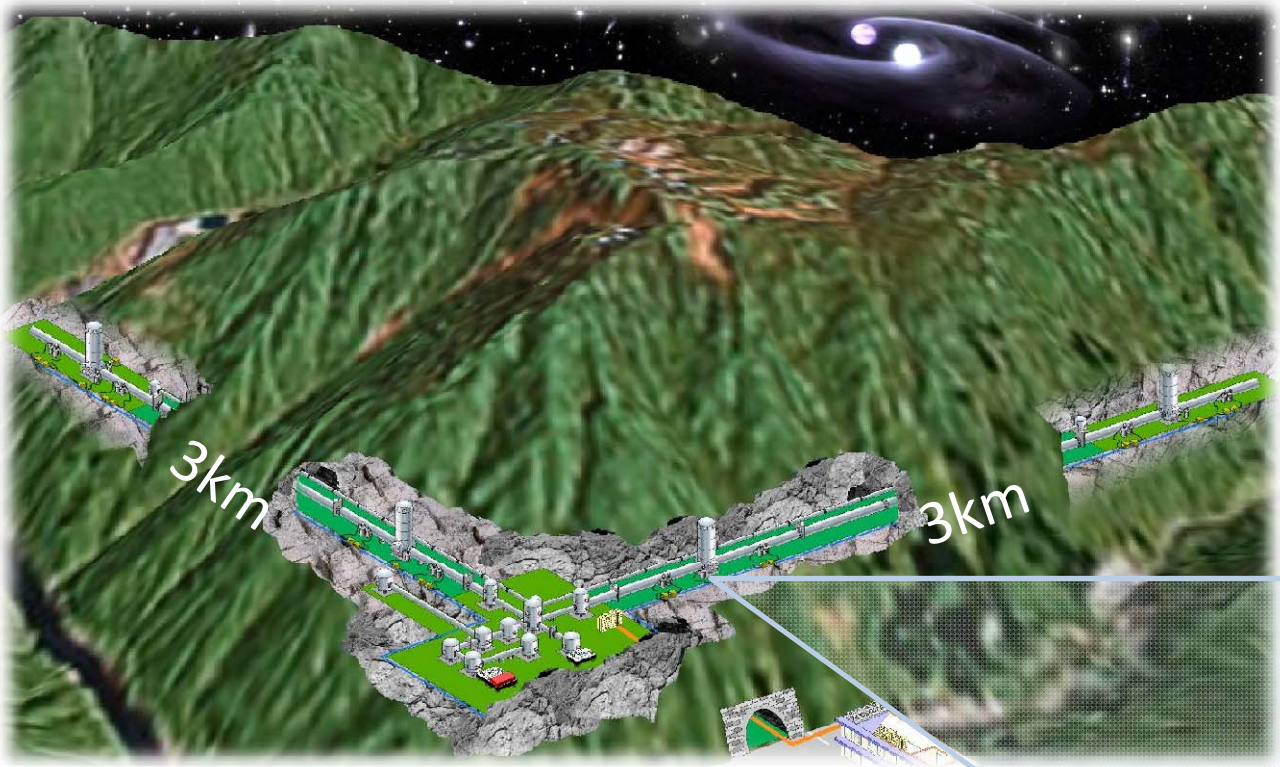
Longer baseline

→ *3km baseline*

→ *optical cavity to increase the effective baseline length*

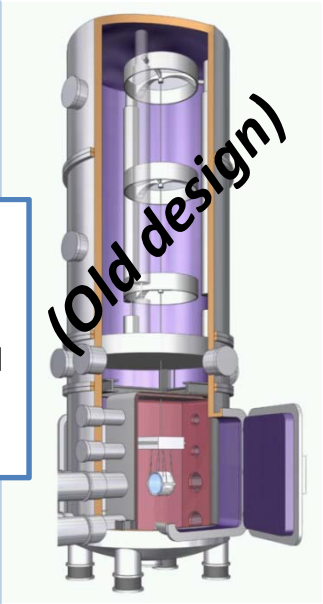


Key features of KAGRA



The detector will be constructed underground Kamioka.
➔ Reduction of seismic noise (to approximately 1/100).

Cryogenic mirrors will be used to reduce the thermal noise (in the 2nd phase).



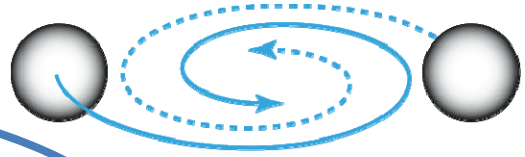
➔ Very high sensitivity.

Location

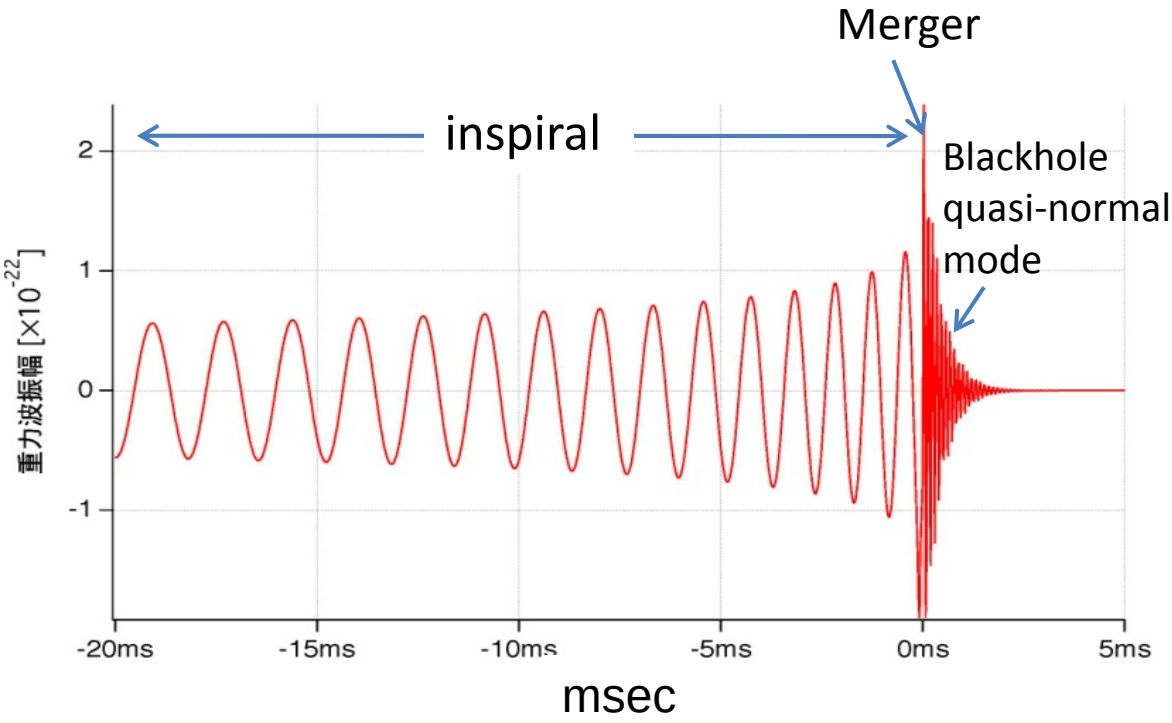

Mozumi
Kamioka
Observatory, ICRR
Super-
Kamiokande
3km
3km
K A G R A
New
Atotsu
Present mine entrance
Toyama airport
40min.
by car
Japan
Tokyo
Yokohama
Nagoya
Mt.Fuji

Sources of Gravitational Waves

1. Coalescence of neutron star binaries
2. Coalescence of black hole binaries
3. Core collapse of massive stars (Supernova)
   (good location; Super-Kamiokande at the same site)
4. Rotation of pulsars



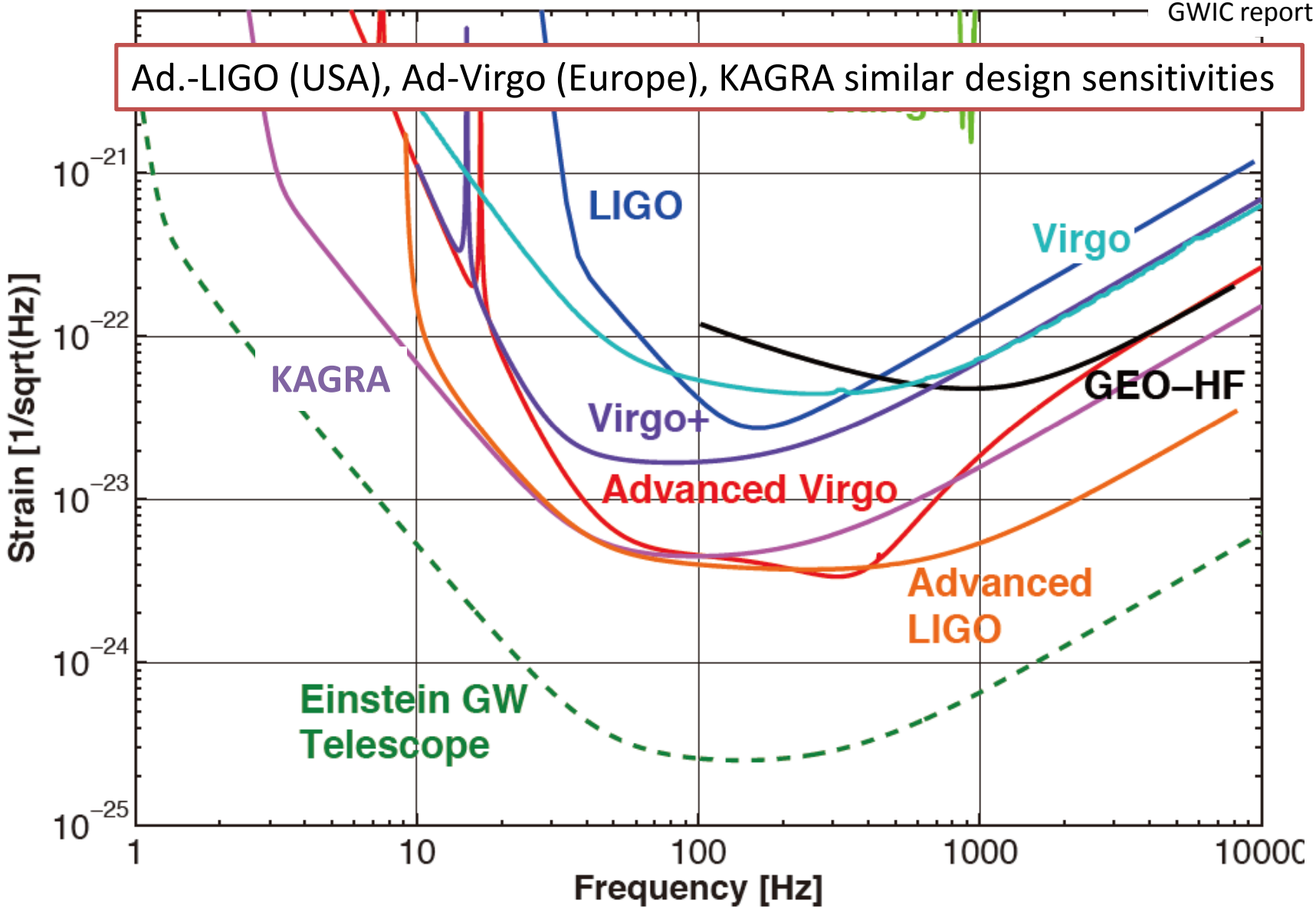
(H. Tagoshi)



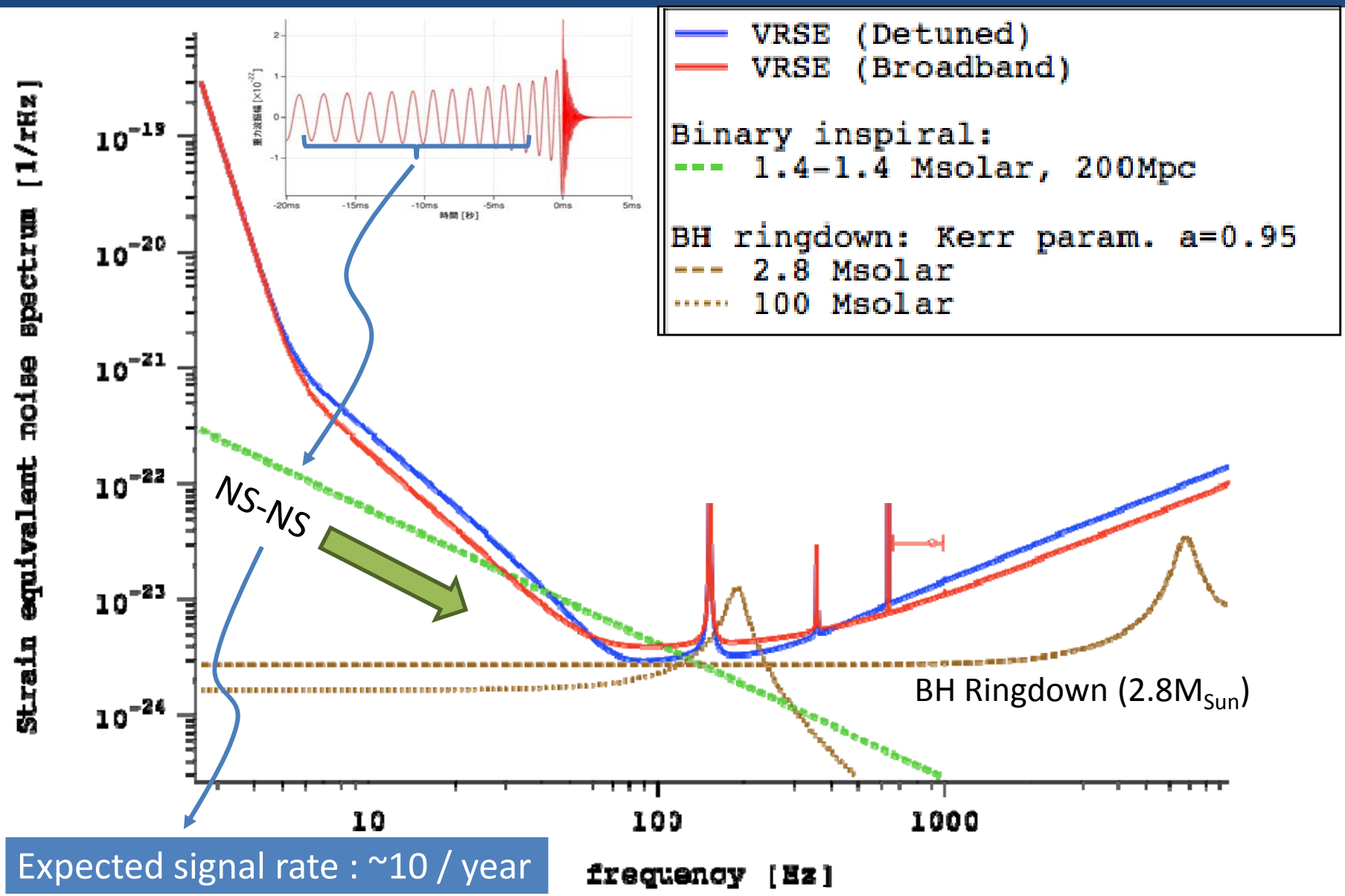
Sensitivities

GWIC report (2010)

Ad.-LIGO (USA), Ad-Virgo (Europe), KAGRA similar design sensitivities



Expected NS-NS Coalescence signal

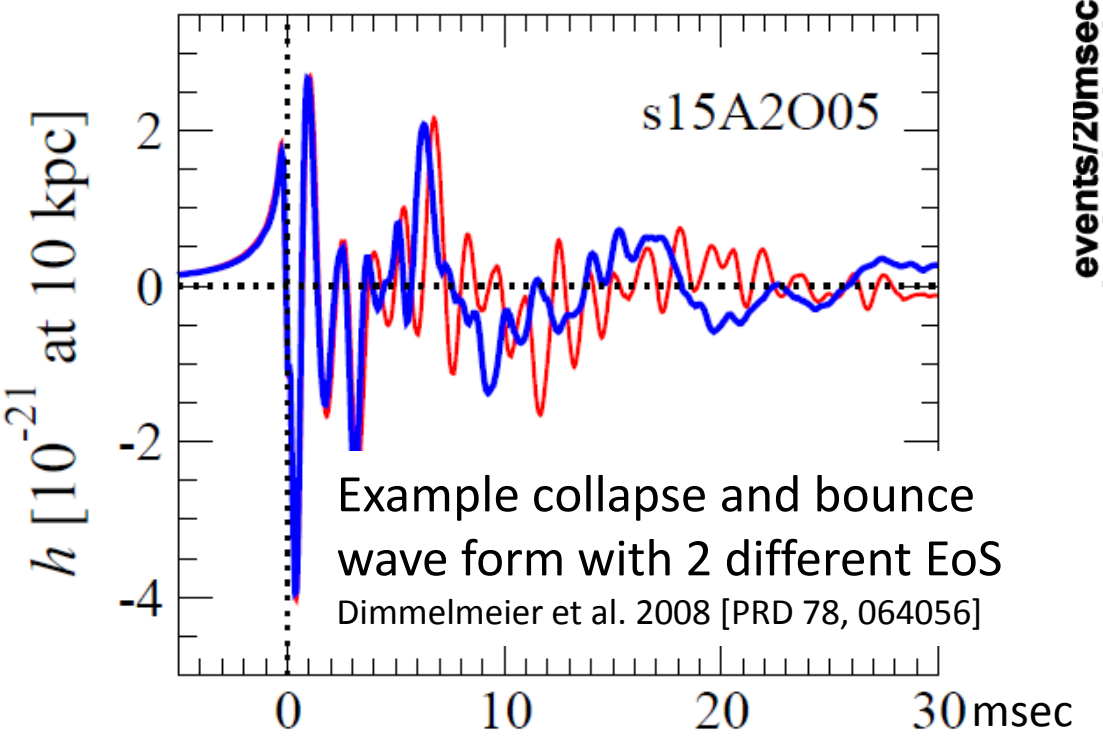


Expected signal rate : ~10 / year

Supernova

Various possible gravitational wave emission mechanism:

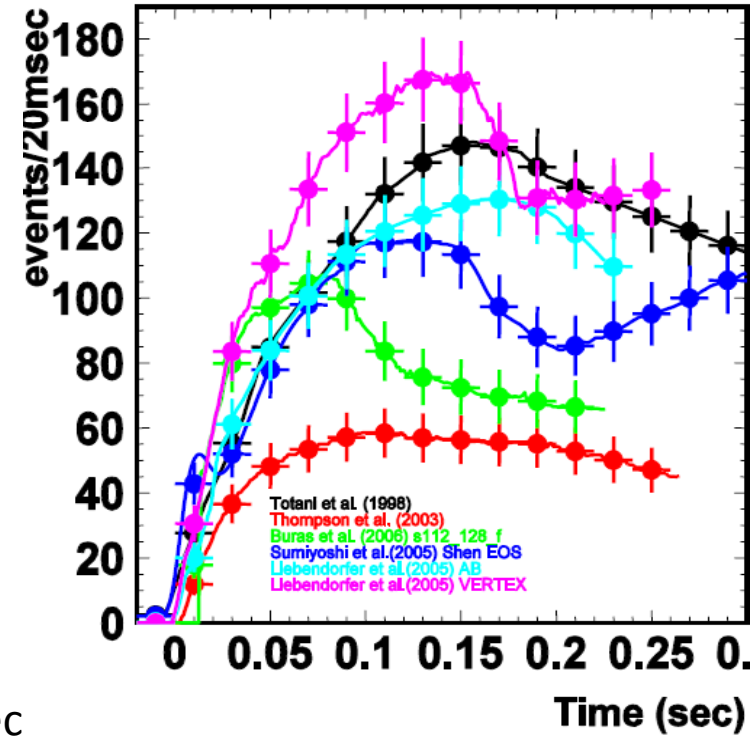
- Core collapse and bounce
- Rotational non-axisymmetric instabilities of proto-neutron star
- Post-bounce convection
- Anisotropic neutrino emission
- …



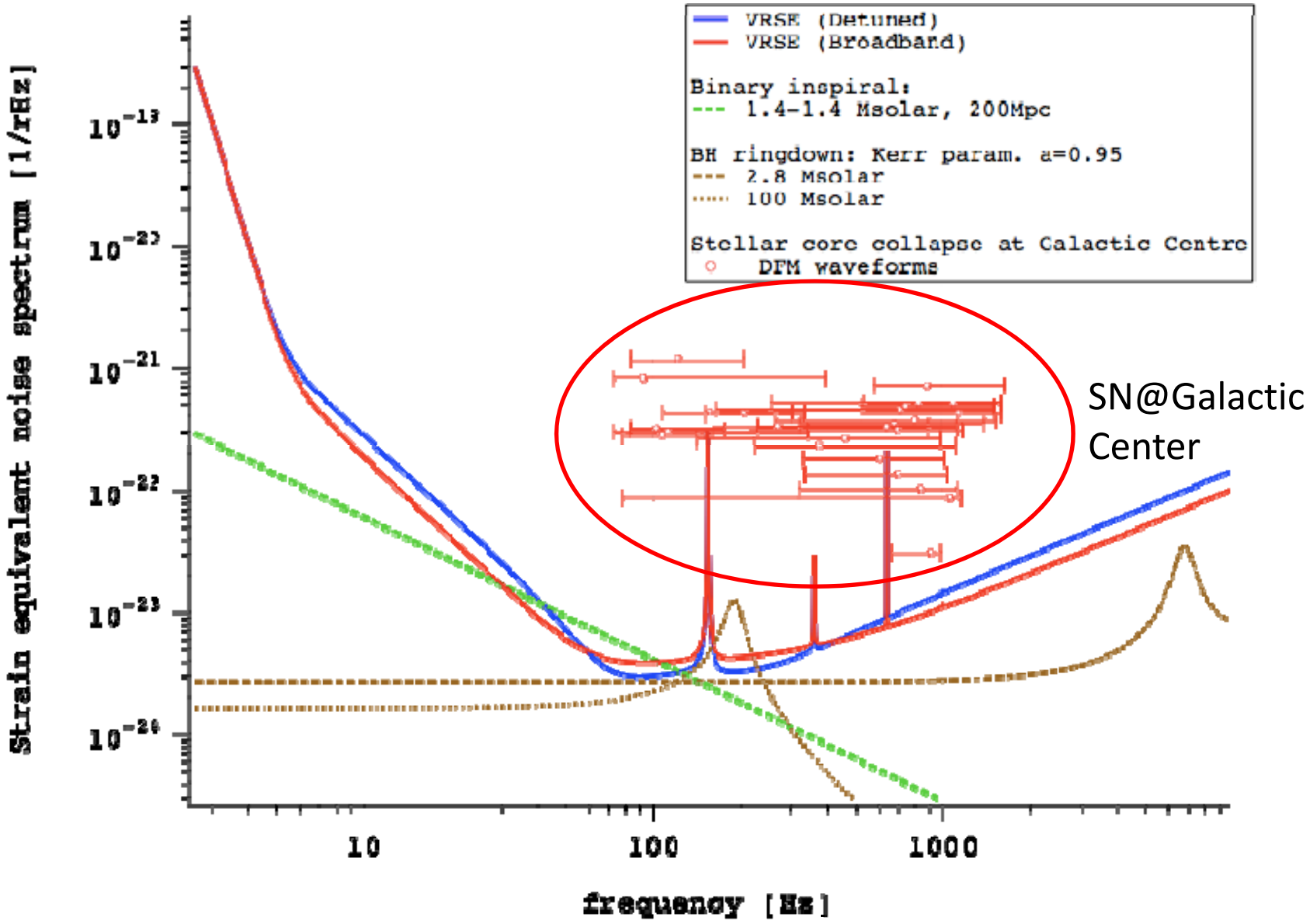
Example collapse and bounce wave form with 2 different EoS

Dimmelmeier et al. 2008 [PRD 78, 064056]

Neutrino (Super-K)

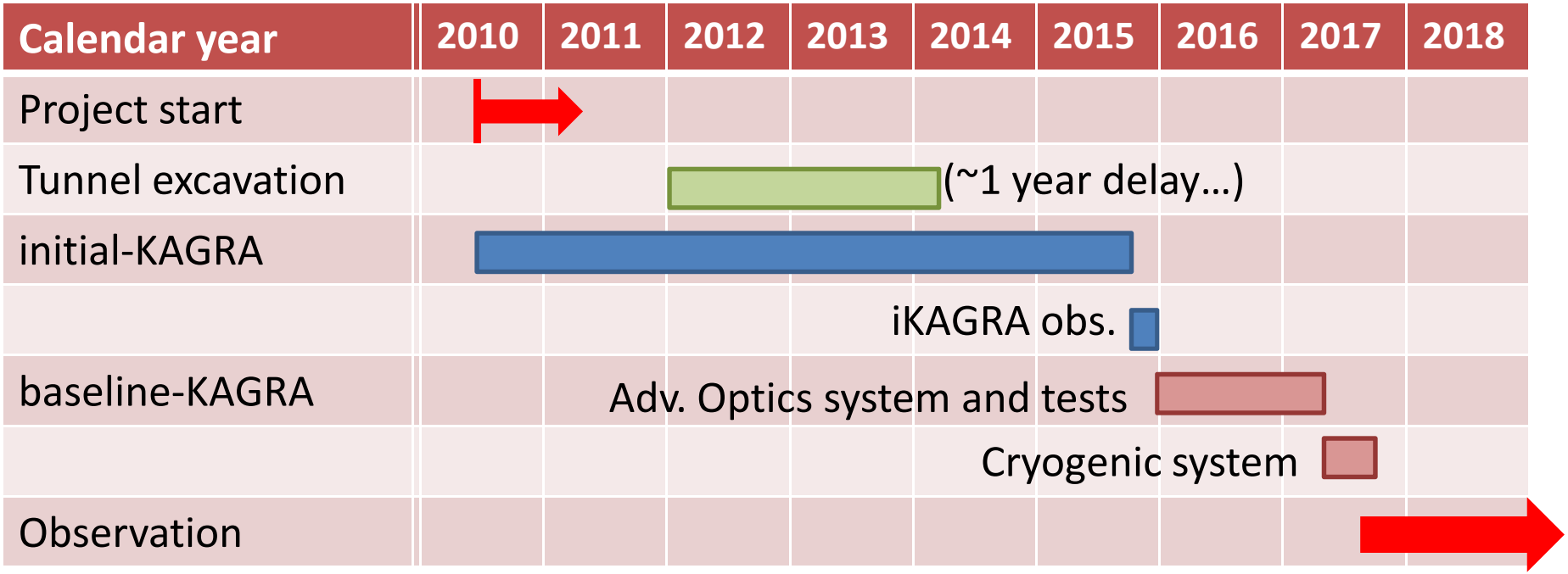


Expected SN signal



SN@Galactic Center

Time line (Construction and Observation)

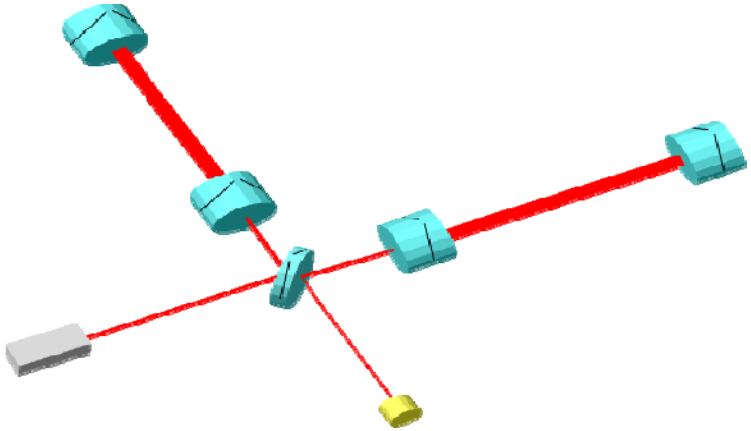


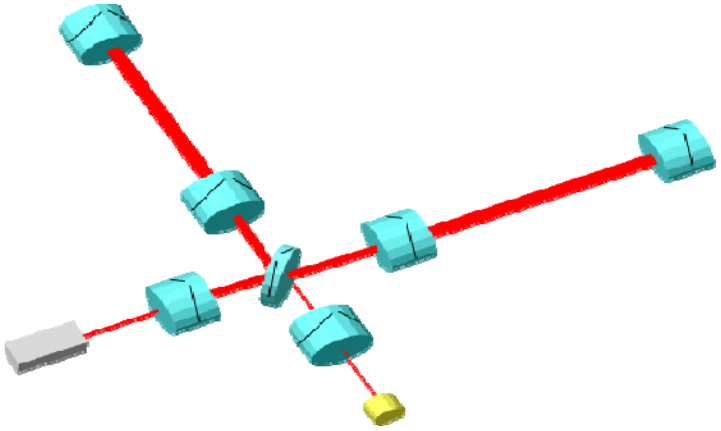
The construction/observation plan is in 2 stages:

- ✓In 2015, non-cryogenic observation (iKAGRA).
- ✓Operation with cryogenic system in 2017 (bKAGRA).
- ✓(High sensitivity operation in 2018?)

iKAGRA and bKAGRA

iKAGRA (~ 2015) → *bKAGRA (2016 ~)*





◆Simple interferometer with:
room temperature operation,
10W class laser, and
no power and signal recycling

◆ However, full end-to-end (relatively short) observation, in order to experience the operation and to understand the potential problems as soon as possible.

◆Advanced interferometer with:
power and signal recycling, but still room temperature operation.

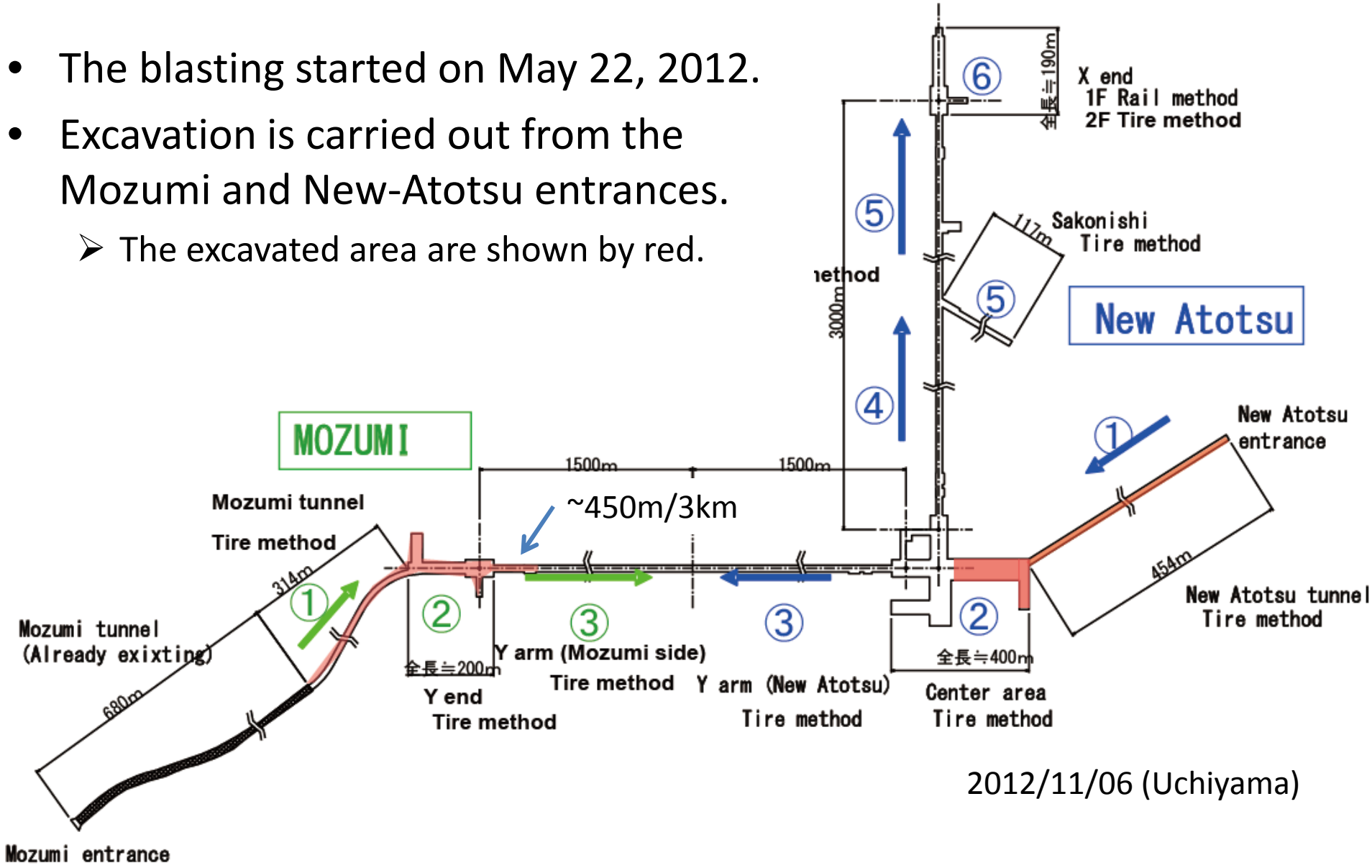
↓

◆ Full bKAGRA with;
power and signal recycling,
cryogenic sapphire mirrors,
and >150W laser.

Status of the KAGRA Project

Tunnel excavation

- The blasting started on May 22, 2012.
- Excavation is carried out from the Mozumi and New-Atotsu entrances.
  - ➢ The excavated area are shown by red.



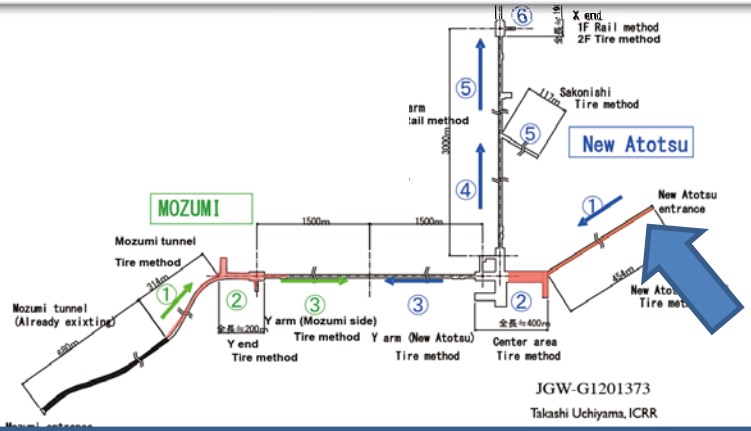
2012/11/06 (Uchiyama)

Tunnel excavation

New Atotsu entrance

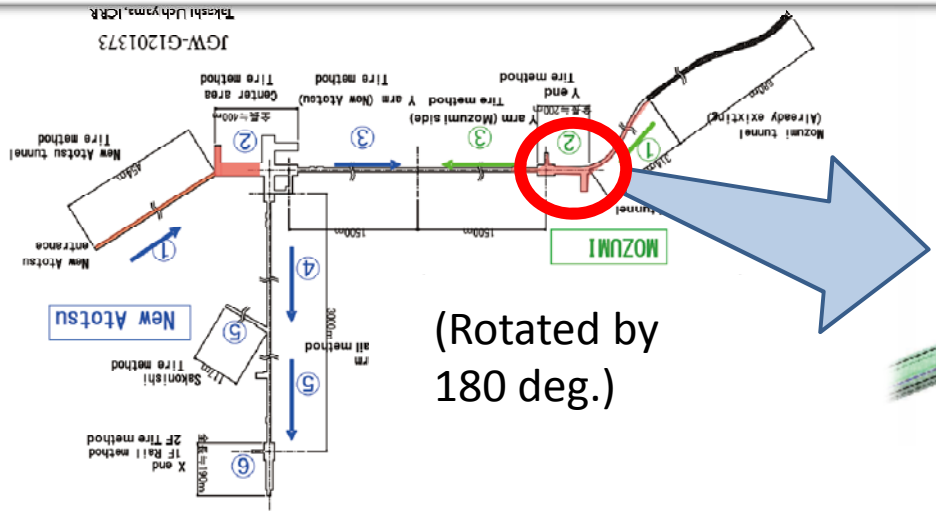
End of April, 2012

Mid June, 2012

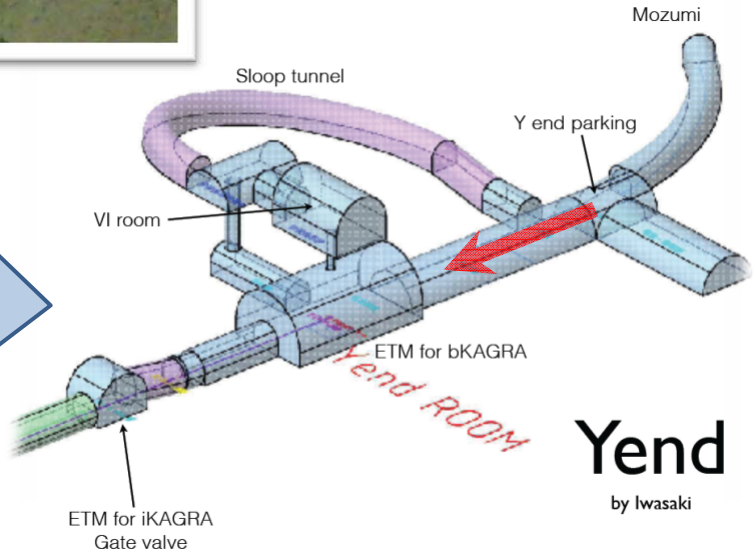


Excavation status (Y-end)

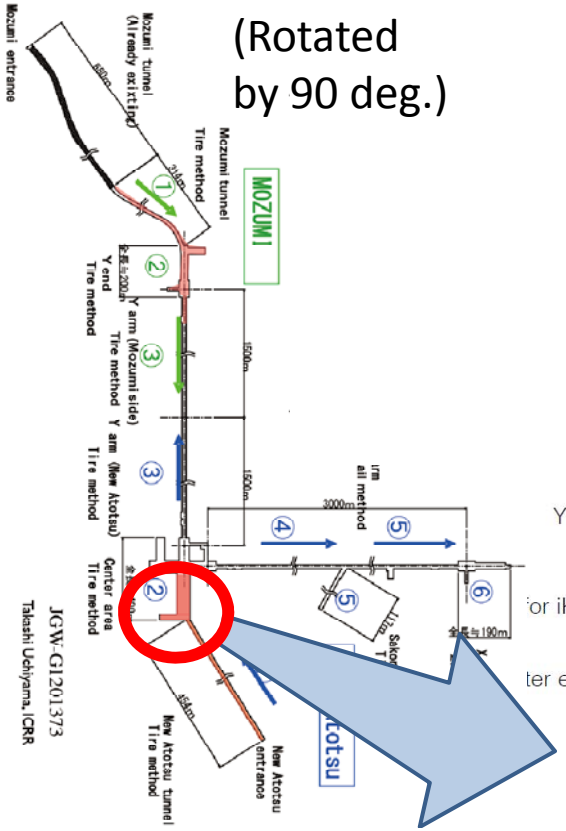
Y-end & Y-arm



(Rotated by 180 deg.)

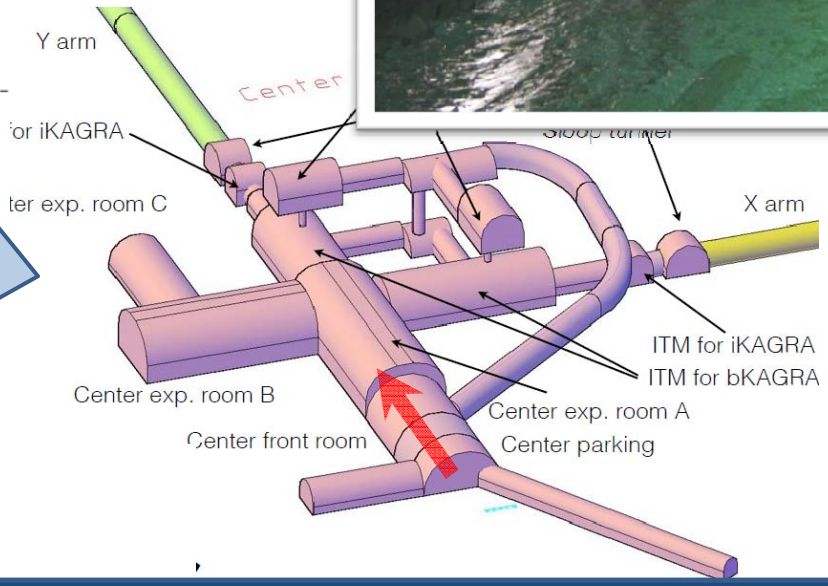


Excavation status (Center room)



(Rotated by 90 deg.)

Center room



Status of construction: Surface building

- The refurbishment was finished in early Aug. We have just moved to this office.

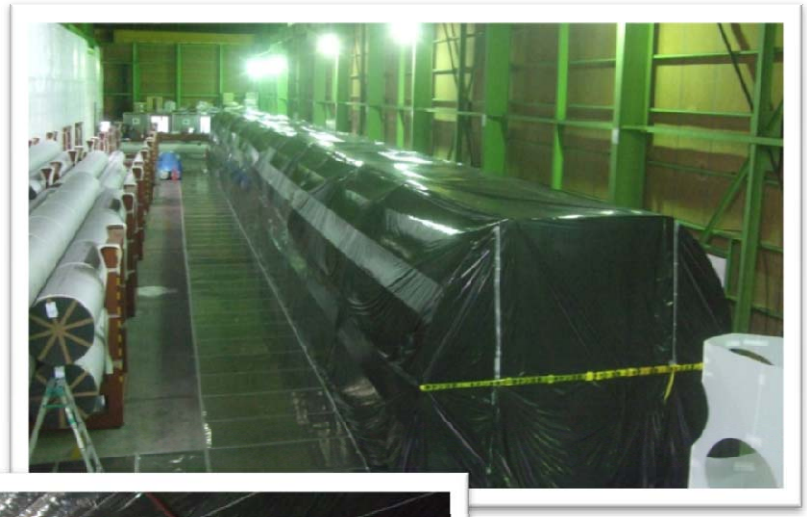
Early June 2012

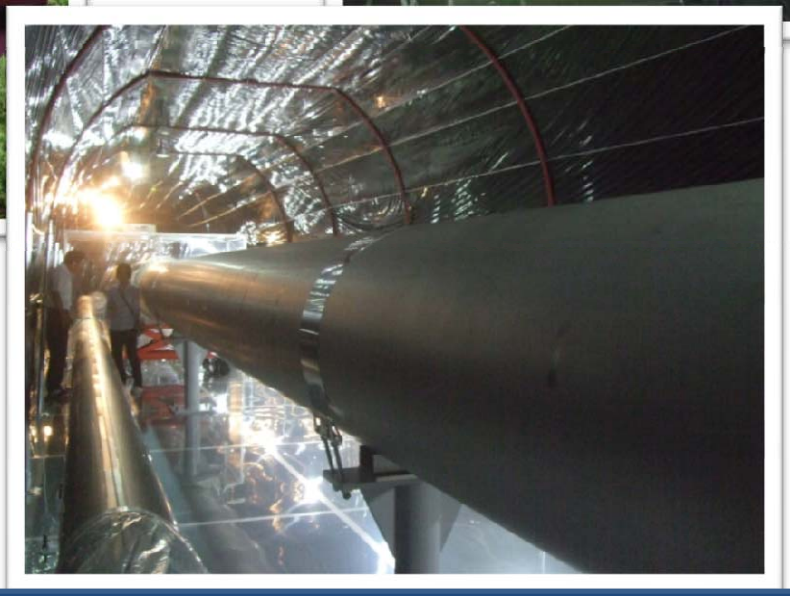
Aug.6, 2012

(Miyakawa, Uchiyama)

Status of preparation: Vacuum

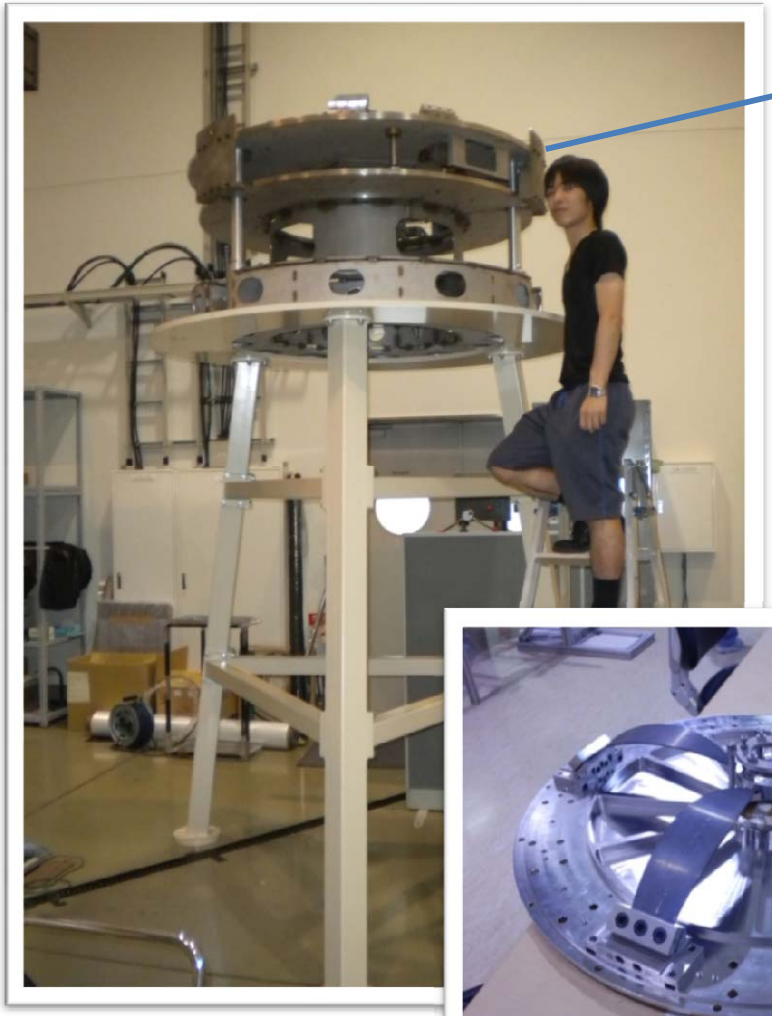
- More than 70% of the pipes (total 6km) are produced and delivered to Kamioka.
- A mockup tunnel has been prepared at a factory near Kashiwa.





(Saito)

Status of construction: Seismic Attenuation

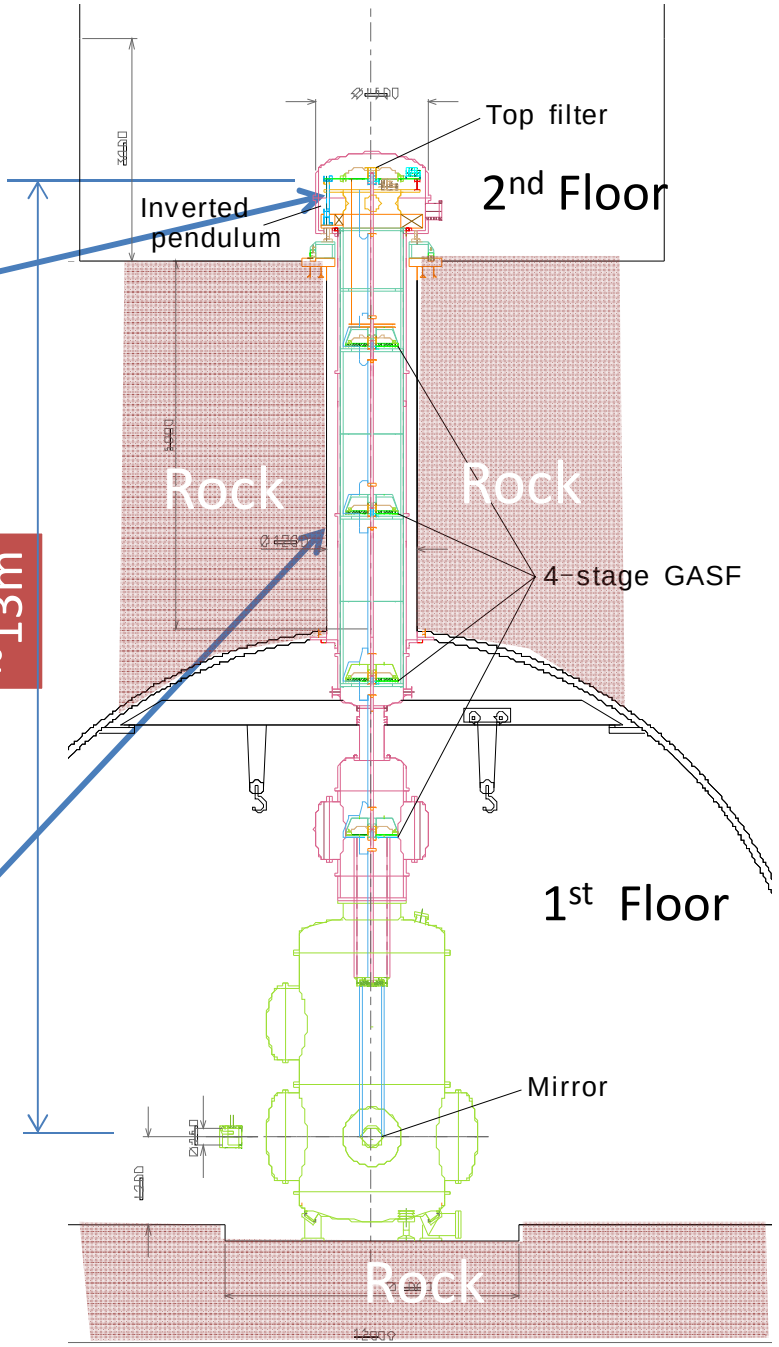


Top filter

Prototypes

Standard filter

(Takahashi et al)



Status of preparation: Seismic Attenuation

Storage & Assembling in Akeno Observatory (ICRR)

Test of Pre-isolator (with the digital control system) at ICRR

Clean booth @Akeno

GAS filters delivered

Status of construction: Cryogenic system

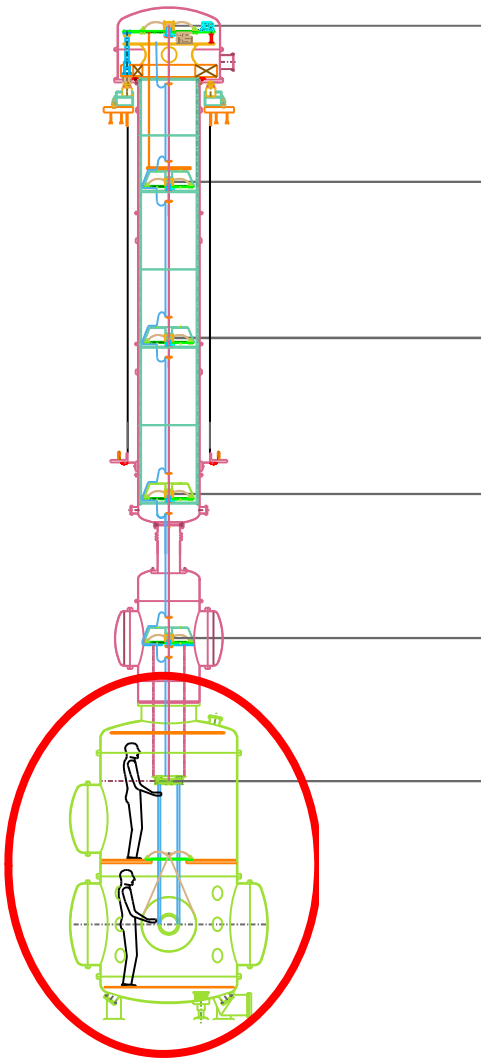
Cryostat
Stainless steel t20mm
Diameter 2.4m
Height ~3.8m
M ~ 10 ton

to Seismic Attenuation system

Double radiation shield

Low vibration cryo-cooler units (4 units)

Main LASER beam



Status of construction: Cryogenic system

Cryostat construction
@Toshiba

Diameter 2.4m
Height ~3.8m
M ~ 10 ton

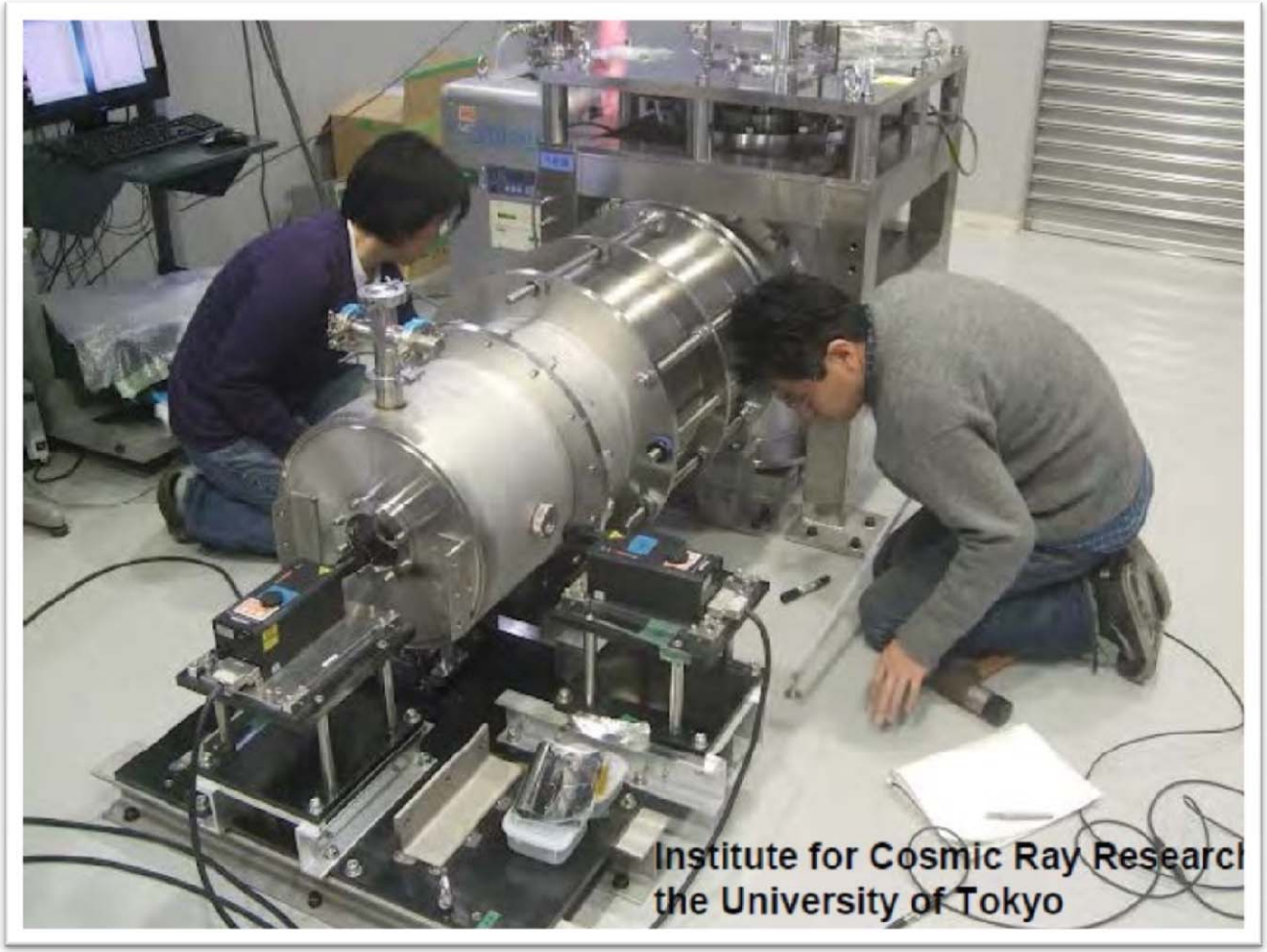
Status of construction: Cryogenic system

Cryostat (Vacuum chamber)
@Toshiba

Shield structure

Status of construction: Cryogenic system

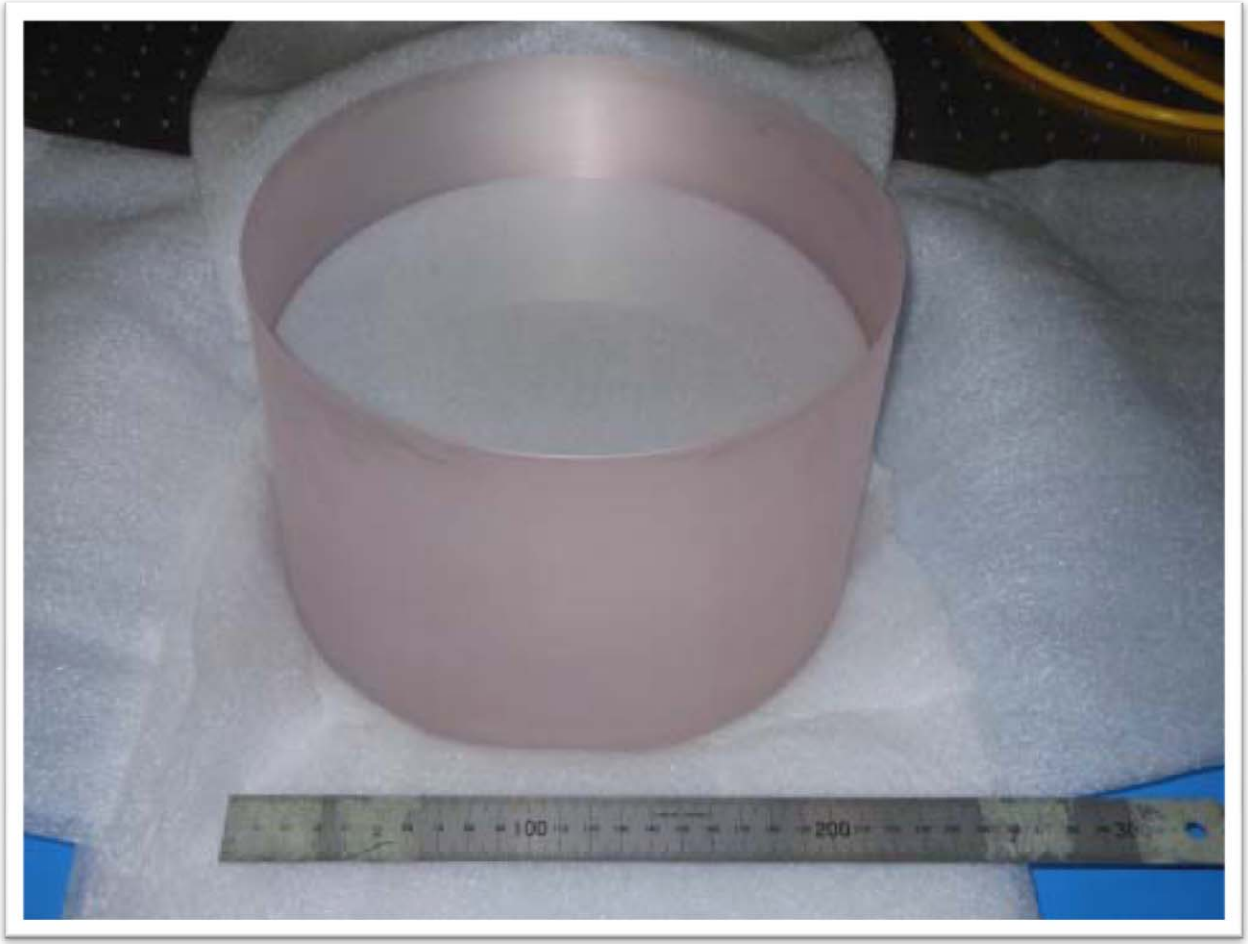
Cryo-cooler unit



Vibration measurement is in progress

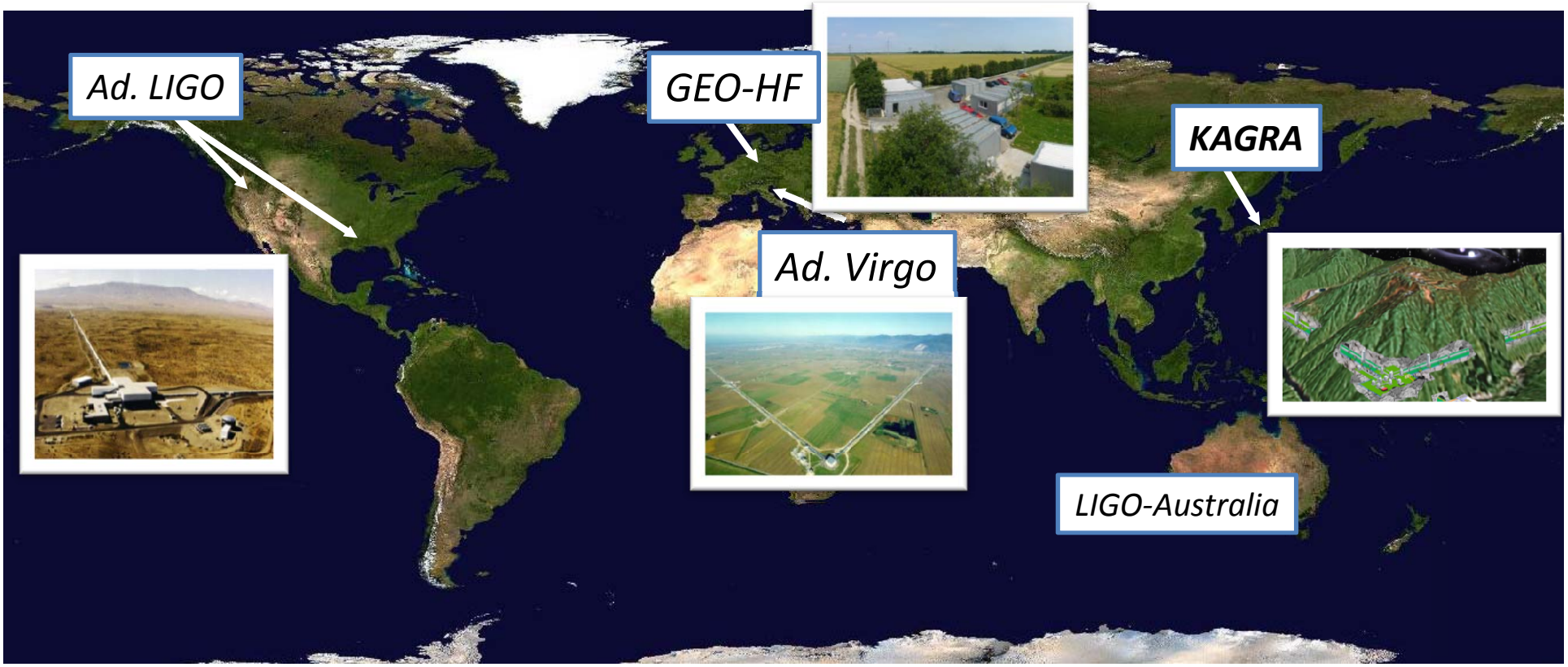
Status of preparation: Sapphire mirror

- First and second Sapphire crystal (C-axis, 22cmϕ, 15cm t) were delivered to Kashiwa in Aug. and Sep. 2012. (We do not know the quality yet…)



(Mio, Hirose)

Joining the global GW network



◆The scientific output will be maximized by the global network.

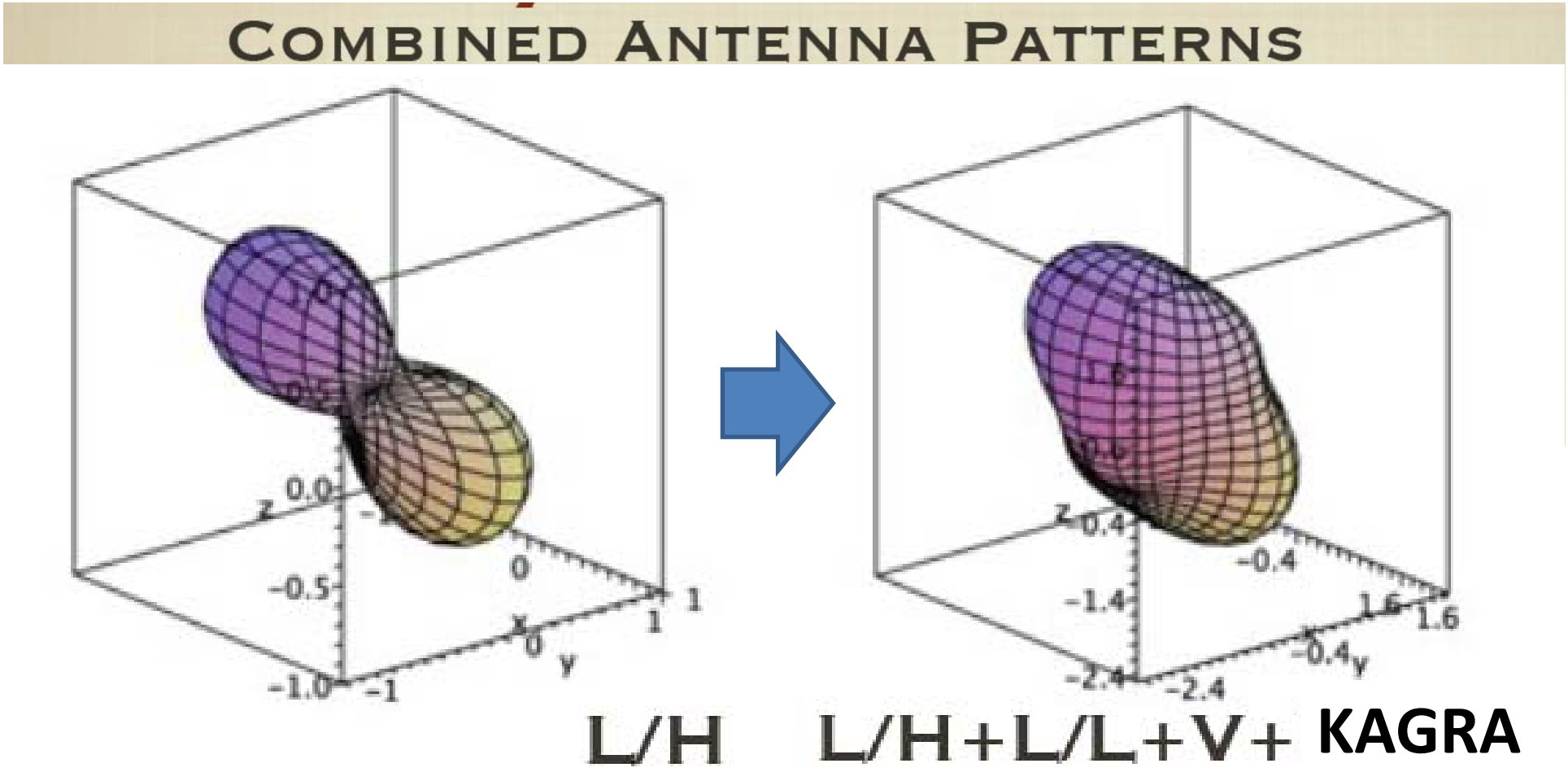
◆KAGRA has to learn various experiences / technologies from the existing interferometers.

◆KAGRA will join the worldwide network of gravitational wave detection / astronomy.

➔ MOU between LSC/Virgo/KAGRA (3 parties agreed.)

Importance of Global GW Network: Sky coverage

B. Schutz (Fijuwara Seminar, May 2009)

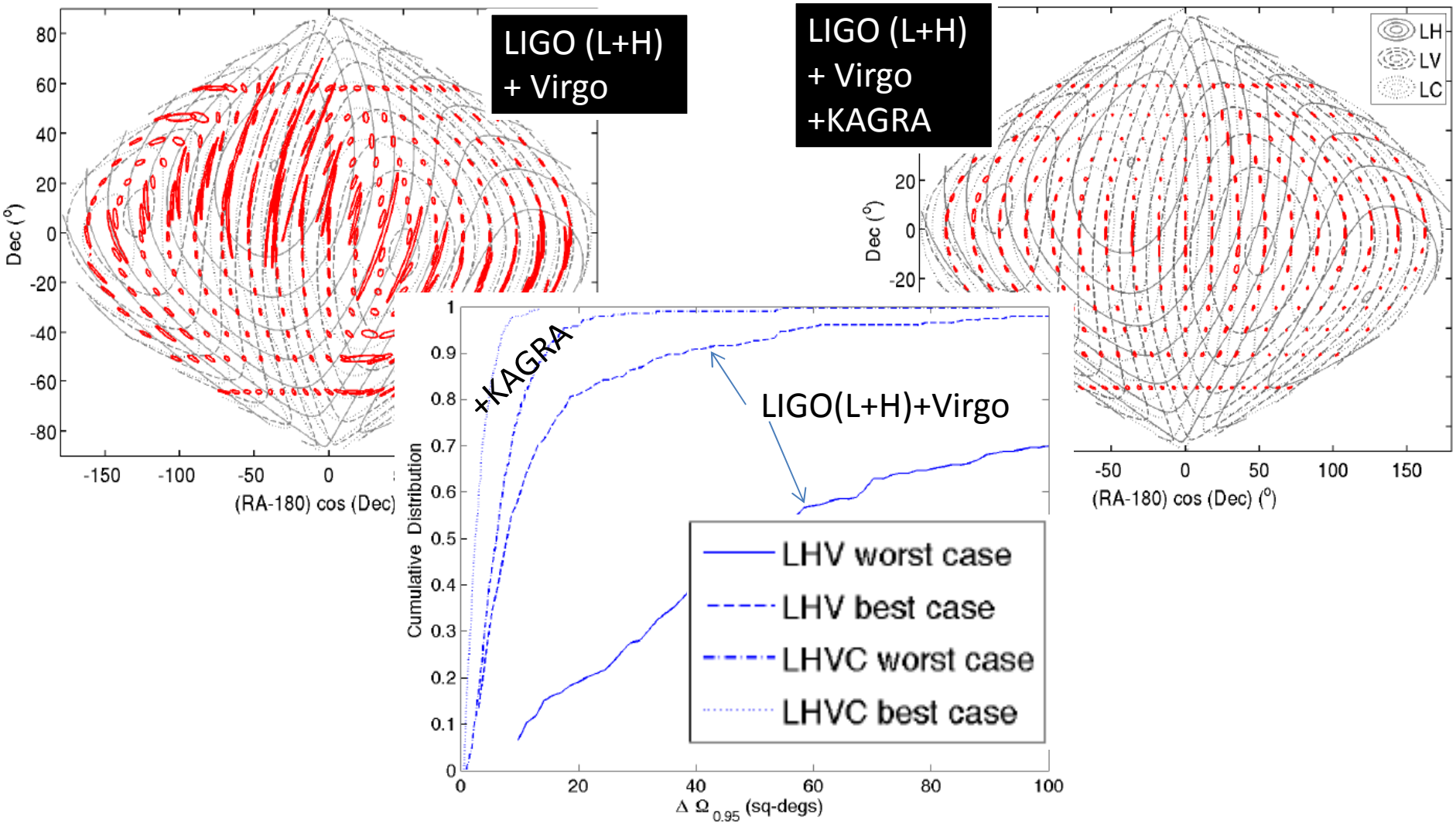


Much wider angular coverage !

Importance of Global GW Network: Angular res.

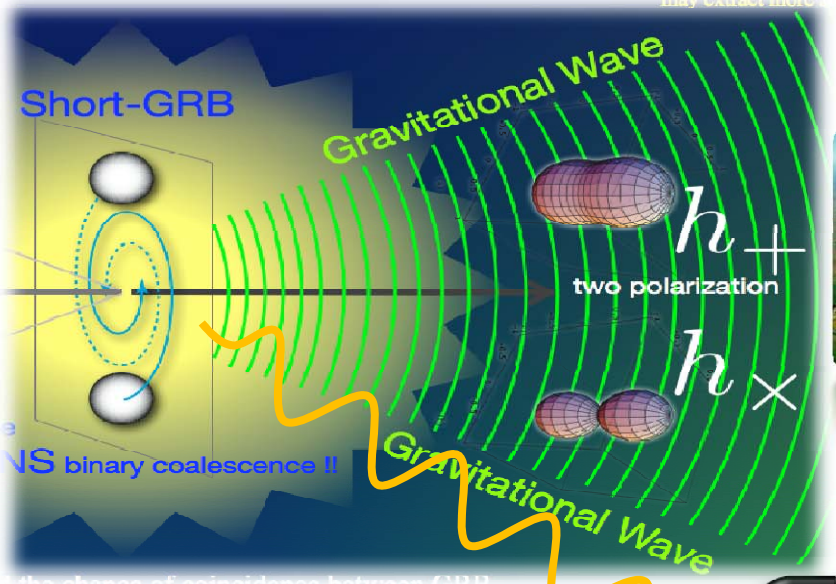
Wen and Chen, arXiv: 1003:2504

Determination of source sky position: 95%CL, supernova, S/N =10

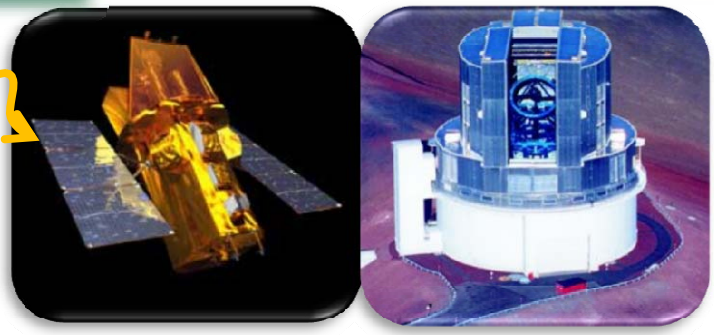


Multi-messenger astronomy: Example: Short Gamma Ray Burst

✓ NS-NS binary might be a progenitor of Short-GRB ?



Gravitational wave (KAGRA, Adv.LIGO, Adv.Vergo, …)



Gamma ray and optical observations

(H. Tagoshi)

Summary

- KAGRA is a unique GW interferometer with the underground site and the cryogenic technology.
- The KAGRA detector construction is in progress.
- Initial operation (iKAGRA) in late 2015.
- Preparation for the cryogenic system is also in progress.
- We plan to start the full cryogenic observation in 2017.
- KAGRA will join the global network of gravitational wave detection/astronomy.